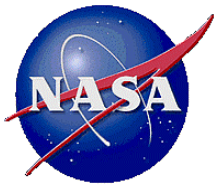
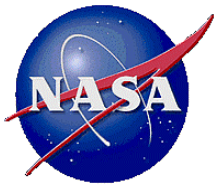


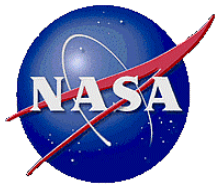
IV&V ISS Test Environment
&
Real Time Simulation Facilities at JSC

Harry St. John
September 17, 2010

Content

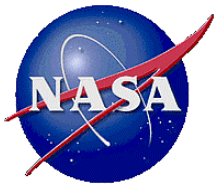


- Introduction to JSC real time simulation facilities supporting Space Shuttle and International Space Station (ISS)
- Common simulation environment and visual environment
- Introduction to the IV&V ISS SW Test Bed



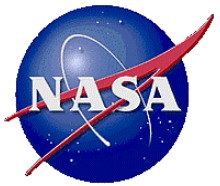
JSC Simulators

JSC Simulators



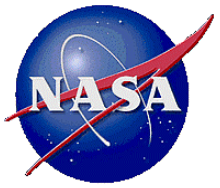
- **Real Time Simulation Facilities used for**
  - Spacecraft design
  - Test and Verification (HW and SW)
  - Operations Support (Procedures Verification/sustaining engineering/anomaly support)
  - Flight and Ground Crew Training
- **Simulator Characteristics – big picture**
  - Engineering Simulators used for design/operations support -- typically high fidelity vehicle/environment models and “functional” flight SW
  - T&V Simulators provide environment to integrate and test flight HW and SW
  - Trainers provide fidelity to simulate vehicle/space environments providing trainees with realistic displays and controls feedback as well as visual feedback– Flight computers and flight software may be real or simulated

Engineering Simulators



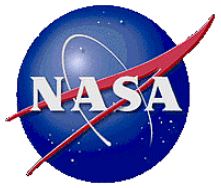
- **Topic is limited to real time simulators versus analytical simulation tools used during spacecraft development**
- **Engineering simulators typically evolve in capability and fidelity during the development lifecycle**
  - Created to meet specific analysis objectives, often times for multiple users with different focus on the vehicle
  - Typical user requirements involve evaluations of man/machine interfaces requiring crew interfaces and visuals
  - Mechanical systems that involve timing critical operations may also be simulated with interfaces to the hardware systems (e.g., docking or berthing hardware) for development support and testing
  - At JSC, engineering simulators are typically developed by special simulation groups based upon user requirements
  - Vehicle system and environment fidelity typically evolve as vehicle design matures, but engineering model fidelity requirements are generally high end
- **Because of functionality, maturity and fidelity, engineering simulators are often used to support operations procedures verification during later stages of vehicle development and during operations**
- **They may also be used as part task trainers to take advantage of simulator fidelity and simulator availability**
- **Also, they serve as sustaining engineering and flight anomaly support tools**

Test and Verification Facilities

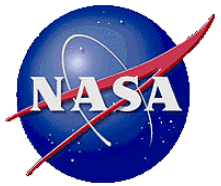


- **Avionics test facilities are operating at JSC for both Shuttle and ISS**
  - Shuttle Avionics Integration Laboratory (SAIL)
  - ISS Software Development Integration Laboratory (SDIL) utilizing the MDM Applications Test Environment (MATE)
    - « ITR… Integrated Test Rig (functions with flight MDMs)
    - « SVF… Software Verification Facility [functions with Functional Equivalent Unit (FEU) MDMs]
- **They test flight software and its interfaces in a high fidelity environment including the use of FEU and/or real flight computers**
- **Where practical, other avionics HW may be integrated in order to provide a high fidelity I/F test environment**
- **Flight computers and SW are exercised in a test environment utilizing simulations, data recording systems and test interfaces**
- **In the case of Shuttle, a cockpit instrumented with flight equipment is utilized for testing involving crew flight operations**

Training Facilities

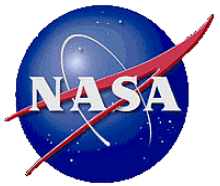


- **Training facilities involving simulators include part task and full task trainers**
  - Part Task Trainers (PTTs) provide specialized training capability for specific systems
  - Full Task Trainers (FTTs) provide the environment to simulate all systems in an integrated fashion as well as interfaces/data to ground control centers
- **PTTs typically utilize simulated flight software whereas FTTs utilize flight software either in flight computers or in flight computer emulators**
- **Simulator fidelity focuses on data and sensory information presented to the trainees**



Common Environments

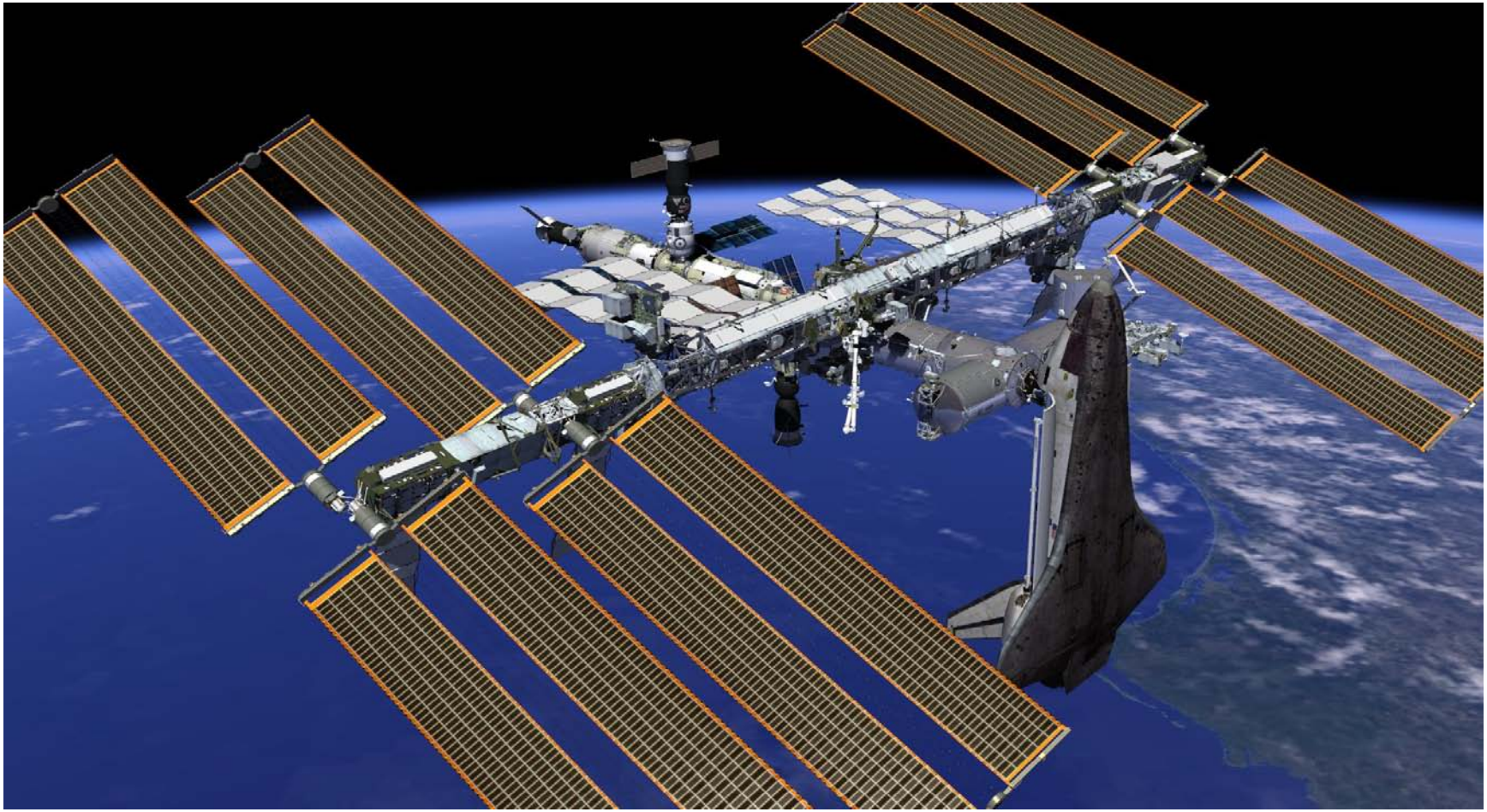
Common Simulator Environments

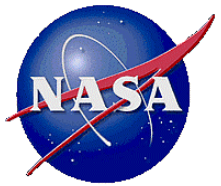


- **Initiative at JSC in the late 90's to introduce efficiencies to real time simulations across JSC including engineering simulators and training facilities**
- **Drivers for the efficiencies:**
  - Problems/costs associated with simulation reuse
  - High cost of visual environment development
  - Desire to move toward PC based simulators
- **Two focus areas**
  - Real time simulation environment developed to enable PC based simulations and ease of portability of applications/models
  - Visual environment also developed for PC based applications with a goal of providing common visual environment and models to JSC simulators
- **Efforts a huge success resulting in**
  - Common simulation environment in engineering simulators for ISS and Constellation; Constellation trainer; ISS Robotics Trainer; Docking/Berthing HW test facility; other part task trainers
  - Common Visual environments for above facilities as well as Space Shuttle and ISS trainers and the virtual reality engineering simulator/trainer
  - Capabilities also provided to MSFC for use in their simulators
- **Why is this of interest to IV&V?**
  - Possible for IV&V to leverage these capabilities if interested in developing internal real time simulation tool capability

Visual Environment Example

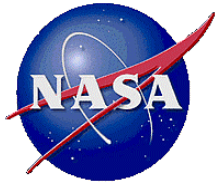
NASA
IV&V
Facility





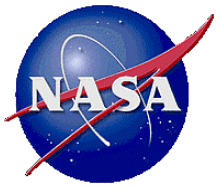
IV&V ISS Test Bed

ISS Test Bed Presentation Protocol



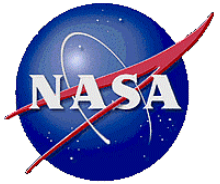
- This ISS Test Bed topic is followed by two others on the same topic
- ISS IV&V Matlab simulation topic follows the test bed topics
- Focus of all four presentations is on the simulations and how we use them to support IV&V work on ISS, and NOT on specifics of the ISS systems
- ISS systems content may be ITAR sensitive and so limit any questions to the simulation tools and how IV&V uses them
- For the first three presentations that focus on the ISS test bed, please hold questions until the three are completed in order to help with time management

ISS IV&V SW Test Environment
Legacy Test Bed



- **IV&V has maintained a test bed capability to test ISS flight SW since ~2000**
- **Test Bed initially developed using ISS Training Facility MDM (ISS Flight Computer) emulator as the means to execute flight SW**
  - Utilizes Single Board Computer running under Linux
  - Capability to run single MDM flight SW load to test at the CSCI level
  - Executes simple systems and environment models, relying on test scripting to develop/execute specific test cases
  - Environment did not support expansion to test SW in multiple MDMs in an integrated mode

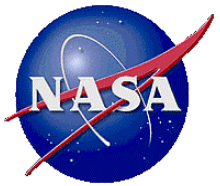
ISS IV&V SW Test Environment
MADE Test Bed



- **Boeing (ISS developer) developed a PC based test environment MDM Applications Development Environment (MADE) that executes flight SW and can be integrated with single or multiple PCs to executed integrated flight SW loads**
  - Operates with single CSCIs or with integrated loads representing SW stages (ISS integrated loads that will operate on orbit)
  - Utilizes system and environment models and relies heavily on scripting for testing (scripts utilized to both provide inputs to “keep the system happy” because of model limitations and also to drive specific test conditions to obtain expected responses from the SW
- **Compliments the ISS MATE which utilizes FEU MDMs executing flight SW but also utilizes common simulation/test script environment as MADE**
- **In 2008, IV&V purchased the hardware and obtained MADE software loads to build the current IV&V ISS test bed**
  - Can utilize copies of configurations run on the Boeing MADE
  - Can execute with single or multiple CSCIs running on a single PC or
  - Can execute multiple CSCIs distributed among dedicated PCs
  - Unique IV&V capabilities to integrate and test any combination of CSCIs

IV&V ISS Test Bed

MADE Presentations Follow



- David Soto will expand upon the requirements, capabilities and test configurations for the IV&V MADE Test Bed
- Paul Vo will provide a demonstration of the MADE Test Bed utilizing a single PC based configuration brought to this conference